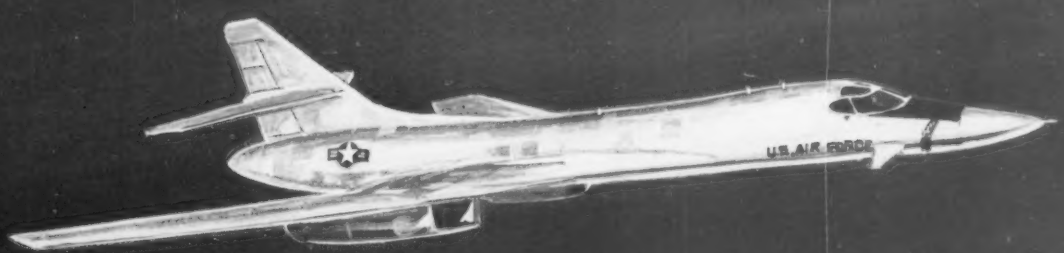
THE NAVIGATOR

AFRP 50-3, Volume XXIII, Number 3, Winter 1976



Brigadier General John W. Hepfer is the Deputy for Intercontinental Ballistic Missiles, Space and Missile Systems Organization (SAMSO), Norton Air Force Base, California. He is the program manager for Minuteman and the Advanced Intercontinental Ballistic Missile (MX). A majority of his career has been spent in the operation and technical development of navigation and guidance systems.

General Hepfer was born in Waynesboro, Pennsylvania, on 9 February 1924. On 10 July 1942, the general enlisted in the Army Air Corps. After receiving his commission through the Aviation Cadet Program, he flew 44 combat missions in the Southwest Pacific as a navigator in B-24s. In 1945, he left the service to attend college receiving a Bachelor of Arts degree in Mathematics and Physics from Bridgewater College, Virginia, in 1950.

With the outbreak of hostilities in Korea, General Hepfer was recalled to active duty. After attending the navigator refresher course at Ellington AFB and the radar refresher course at Mather AFB, he was assigned to combat crew training for B-29s at Randolph AFB.

In 1952, the General was selected to attend the Air Force Institute of Technology where he obtained a Bachelor of Science degree in Electrical Engineering. Remaining at Wright-Patterson AFB, the General was assigned to the Communications and Navigation Laboratory where he was able to apply his operational navigation experience and academic background to the development of inertial navigation equipment. His flying time involved the flight testing of doppler radars, automatic star trackers, DR Computers and other new projects. He was also the project officer for the Navaho Missile Guidance and Control System. "This was my first association with pilotless aircraft and inertial navigators. Little did I know how involved I would be with both today."

In 1957, he was assigned to the Air Research and Development Command (ARDC) which later merged with some elements of the Air Materiel Command to become Air Force Systems Command (AFSC). The General served with both ARDC and AFSC as an Assistant for Bombing, Navigation and Missile Systems. During this time, General Hepfer accumulated over 5500 hours of flying time navigating as an additional duty.

From 1962 to 1965, he was the Program Monitor for Bombing, Fire Control and Navigation Systems with the Research and Technology Division (RTD) at Bolling AFB, Washington DC. While at RTD, General Hepfer helped setup the AFSC Laboratory System that exists today. In 1966 he was assigned to the Institute of Defense Analysis where he received a Master of Arts degree in Quantitative Analysis from the University of Maryland.

From 1966 to 1967, he was assigned to the Defense Communications Agency (DCA), assigned with the mission of building an electronic defense barrier across Vietnam. In June 1967,the General was assigned to the Space and Missile Systems Organization's (SAMSO) Minuteman Systems Project Office at Norton AFB, California. After serving as Chief of Guidance and Control for Minuteman, he became Deputy Chief of Engineering for Systems. "In my present job as Deputy for Intercontinental Ballistic Missiles I have had the pleasure of seeing many of the projects that I started come to fruition, but occasionally I am reminded by my project officers that not all of them were 100% successful."

Between assignments at SAMSO, General Hepfer attended the Air War College and was the Assistant Deputy Chief of Staff for Systems at Headquarters Air Force Systems Command. After leaving HQ AFSC, he commanded Rome Air Development Center, Griffiss AFB, New York.

General Hepfer has been at his present assignment since January 1974. "It is a unique assignment in systems acquisition. We have an active production and deployment program in the Minuteman System and we are transitioning from the conceptual phase to the validation phase of a completely new missile program, the MX."

General Hepfer is married to the former Janet L. Miller of Waynesboro, Pennsylvania. They have two sons, John W. III and Stephen. Stephen is now entering his third year at the United States Air Force Academy.

When asked what the ingredients are for a navigator's success, he replied: "They are the same for any officer—use your spare time to gain education, both formal degrees and professional military education, and, most important, always work for your boss—try to make his job easy."

NAV OF NOTE

From The Editor

MEET YOUR NEW EDITOR: Captain John N. McClain is a 1965 graduate of the University of Arkansas, Little Rock, where he majored in Political Science and Business Administration. He was commissioned in March 1966 from Officer Training School and received his wings at Mather Air Force Base, CA in January 1967. After attending Navigator Bombardier Training he was assigned to the 5th Bomb Wing at Travis Air Force Base, CA, with the Strategic Air Command. Captain McClain was later transferred to Dyess Air Force Base, Texas and the 96th Strategic Aerospace Wing (SAC). During these assignments Captain McClain was a navigator, radar navigator, and flight examiner in the B-52, and participated in four Southeast Asia B-52 Arc-Lite tours. He also attended Squadron Officer School at Maxwell Air Force Base, AL. Captain McClain came to Mather AFB, CA in February 1973. Prior to his present duty as Editor, he was the Curriculum Liaison Officer in the 449th Flying Training Squadron (Nav Bomb Training). He is married to the former Lynn Oster and they have two children—a son, Lee (age 5 years), and a daughter, Jae (age 13 months).

EDITORIAL

As the new editor of THE NAVIGATOR, I realize the dependence we have on you, the reader. I solicit your support, through articles and comments, in maintaining THE NAVIGATOR as one of the best recurring publications in the Air Force.

This issue focuses on the newest aircraft proposed for the Air Force inventory, the B-1 Bomber. At press time, the final decision on full production of this advanced weapon system had not been made. This article, "A Test Nav Looks at the B-1," gives an insight into the B-1 avionics through the eyes of the Offensive Systems Operator.

"Low Level Techniques" gives tips on flying a safe and successful low level mission, from a navigator who is now a F-111 pilot.

Other articles have been selected with your reader survey cards in mind. Hopefully, you will find them informative and rewarding. If you have any comments or would like to submit an article for publication, my address is:

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CONTENTS

Nav of Note 2

A Test Nav Looks at the B-1 5

Low Level Techniques 12

Fine Tuning Your INS 16

Celestial Competence 21

Bicentennial Visit to the RAF 22

Star Identification 24

The Team: Operations and Maintenance 29

Mather Gets a Navigator Commander 31

AFRP 50-3

THE NAVIGATOR cover depicts a penetrating B-1, our newest strategic aircraft, as it releases a SRAM missile. Three of the aircraft are currently undergoing flight tests at Edwards AFB CA. For a look at the B-1 avionics and some observations from an Offensive Systems Operator involved in the testing, see story on page 5.

A TEST NAV LOOKS AT THE B-1

Lt Col Kenneth W. BROTNOV
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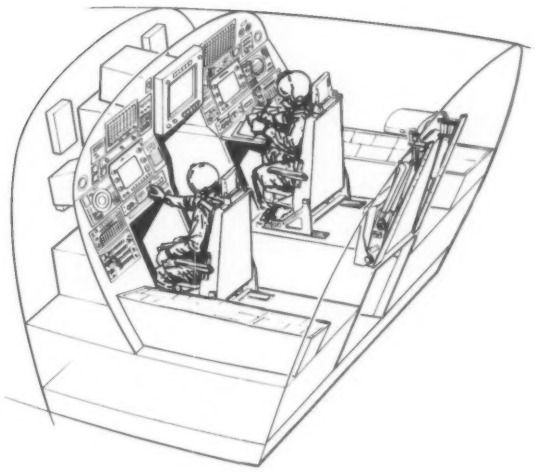


On April 1, 1976, the morning was cool, clear and quiet, typical of the high desert of Southern California. I was standing by the run pad at Plant 42 in Palmdale, waiting to climb aboard for the first flight of the second B-1 to fly.

The first B-1, No. 40158, had flown shortly before Christmas, 1974. It had already had a good year of basic flight testing, including airspeed calibrations, basic aircraft systems checkout, handling qualities evaluation, stability and control work, flutter checks, aircraft performance and a general expansion of the airspeed and altitude envelope in which the aircraft was allowed to fly. The second B-1, No. 40159, had been heavily instrumented with strain gauges and then loaded and stressed in a series of ground static tests. It was being readied for a first flight in June, after which it would continue as the primary flight loads test aircraft. The third B-1, No. 40160, was the one waiting to fly that morning.

This aircraft had something special not found in the other two: an avionics complex of inertial units, computers, attack radar, Doppler radar, terrain following radar, and infrared sensors. This was the first B-1 to carry the offensive

LEGEND

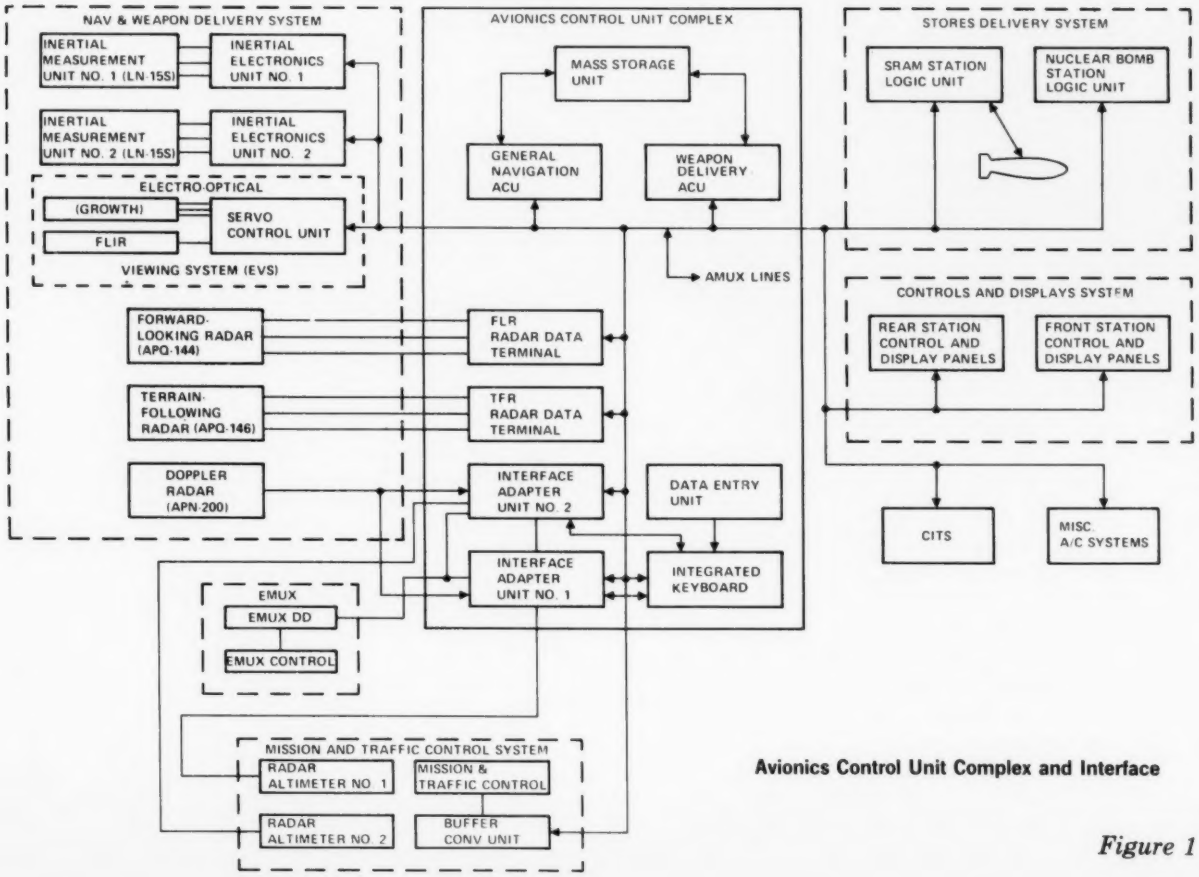
ACU - avionics control unit
ACUC - avionics control unit complex
ADF - air direction finder
AILA - airborne instrument landing approach
AMUX - avionics multiplex
BDA - bomb damage assessment
CADC - central air data computer
CEP - circular error probable
CITS - central integrated test system
CRT - cathode ray tube
DEU - data entry unit
EMUX - electrical multiplex
ETA - estimated time of arrival
ETE - estimated time enroute
EVS - electro-optical viewing system
EWO - emergency war order
FLIR - forward looking infrared
FLR - forward looking radar
GFE - government furnished equipment
GNACU - general navigation avionics control unit
HF - high frequency
HSI - heading stabilization indicator
IKB - integrated keyboard
ILS - instrument landing system
IMU - inertial measuring unit
LRU - line replaceable unit
MSU - message switching unit
OAP - offset aiming point
OFS - offensive flight software
OSO - offensive systems operator
SLU - station logic units
SMS - stores management system
SPO - system program officer
SRAM - short range attack missile
TFR - terrain following radar
UHF - ultra high frequency
VSD - vertical situation display
WDACU - weapon delivery avionics control unit

avionics, and its primary flight test purpose would be the test and evaluation of that system. Major Fred Black, of SAC, and I would share the sorties during Phase I of the flight testing. We would not be called the navigator or the bomb aimer, but the Offensive Systems Operator, or OSO, which is Spanish for "bear."

Standing with the rest of the crew, I felt a little like the new kid on the block. The pilot would be Charlie Bock, Chief Rockwell test pilot and a retired Air Force colonel. He was one of the first USAF test pilots in both the B-58 and the SR-71. The copilot would be Lt Col Ed McDowell, test pilot on the FB-111 and the A-37. The Rockwell flight test engineer would be Dick Abrams, who served in this capacity on the B-58, the SR-71, and the Concorde (for the FAA).

The four of us, however, were just the tip of the iceberg. Behind us on the edge of the run pad was a bus full of engineers monitoring the aircraft. Ahead of us, many maintenance men, engineers, and ground crewmen were working around the aircraft. Additional credit belongs to the engineers at Los Angeles and Seattle who designed the aircraft, the shops and subcontractors that built various devices and parts, and many other engineers who had done the planning for this first test flight and were now at Palmdale and Edwards, ready to monitor it. All of their diverse efforts were now distilled into one plane and four people. Like that part of the iceberg that lies beneath the surface, they were the support for the small part that would be most visible.

Boeing, the prime avionics contractor, took the individual pieces of government furnished equipment (GFE), [such as the inertial measuring units (IMU), forward looking radar (FLR) and Doppler] and integrated them into a working navigation and bombing system. They determined the signal level and signal input/output characteristics for each piece of equipment. If the signals did not match the voltage or signal requirements of the avionics computers, a buffer/signal conversion unit was provided. The avionics computers were obtained and the offensive software to tie it all together was provided by Boeing. Two mockups of the



Avionics Control Unit Complex and Interface

Figure 1

system were built in Seattle, and the entire software package was checked out. One of the mockups was then moved to Palmdale for aircraft checkout and crew training. (After the first flight, the mockup was moved to the Boeing Mojave Test Center at Edwards AFB for use in checking out software changes, trouble shooting, and crew training.)

The design of the navigation and weapon delivery subsystem followed the basic B-1 design philosophy of fail operational-fail safe. In the aircraft this means that enough redundancy is provided in the essential systems so that with one failure the aircraft will still be fully operational. If another failure occurs in the same area, the aircraft still will be able to return to base and land safely. The same redundancy is present in the B-1 avionics system which includes two computers, two IMUs, and a dual channel terrain following radar (TFR). (Figure 1)

The B-1 navigation system uses two independent LN-15S IMUs, modified versions of the IMU used in the B-52G/H. The IMUs can be ground or air aligned and are compatible with the SRAM. They provide aircraft vertical reference, local velocity, and heading reference signals to the computers. The computers, in turn, send back the gyro torquing signals required to maintain the IMU alignment.

The Electro-Optical Viewing System (EVS) consists of a forward looking infrared (FLIR) system. The FLIR provides a stabilized picture 60 degrees either side of the aircraft centerline. It can be controlled by the pilots, by the OSO (through the tracking handle), or by the computer. When controlled by the computer, a FLIR fix update can be made by designating a target at two different pointing angles. The FLIR picture may be selected on the pilot's vertical situation display (VSD) and at the OSO station. It is displayed on a TV format with azimuth and elevation scales along the left side and bottom of the picture.

The FLR is a modified AN/APQ-144, the same radar in the F-111F. The scan has been increased slightly in azimuth and sweeps to ± 60 degrees about the aircraft centerline. It has a manual mode and two automatic tracking modes, one with a normal sector scan and one with an expanded view around the cross hairs, and an air-to-air tracking mode. It has excellent resolution and is particularly suited to low level navigation and bombing.

The TFR is the AN/APQ-146, the same as that in the F-111F. It has the same controls, displays, and built-in safety features. Six terrain clearances from 1000 feet to 200 feet may be selected, along with soft, medium or hard ride. An automatic letdown to the preselected terrain clearance can be made, and, if the aircraft flies below a predetermined percentage of the set clearance plane, or if a fault is detected, an automatic flyup is initiated. The TFR algorithms, the equations that govern the commands to the aircraft, have been changed for the B-1. They determine how far back from the hill the commands are initiated, the rates of pull up or push over, and other factors that must be tailored to the dynamic response of the aircraft.

The Doppler used in the B-1 is a modified AN/APN-200. It provides ground speed and drift to the computers and drift to the TFR. The AN/APN-200 is a state-of-the-art radar which uses IMPATT diodes instead of a magnetron. It has no moving parts and uses a micro processor for resolving drift and ground speed.

The radar altimeter is the APN-194. It provides absolute altitude readings from 0-5000 feet and warns if the aircraft descends below a preselected altitude. It is a dual-channel unit and provides readouts on the radar altimeter indicator, the pilot's VSDs and the nav panel. The signal is also provided to the TFR for use when flying over water or terrain which has low radar reflectivity.

The heart of the avionics system is the avionics control unit complex (ACUC). It takes the information from the various sensors, sorts it, checks it for validity, and performs navigation, bombing and other computations. It then sends the results out to the various displays, back to the sensors, or to the other aircraft systems that use navigation and attitude information.

There are two avionics control units in the ACUC: the general navigation ACU and the weapon delivery ACU. They each have approximately a 32K memory, five serial digital multiplex channels for communicating with the other system components, and two parallel input/output channels for communicating with the mass storage unit (MSU). The GNACU normally does the solutions to the various navigation equations while the WDACU concentrates on bombing computations, weapon status, and weapon tables. They exchange data continuously, however, and either computer can take over the whole computation task if the other should fail.

The MSU provides additional storage capacity for both computers. The entire offensive flight software (OFS) is stored in the MSU so it can be used to reload either ACU if necessary. Various

redundant programs, navigation and weapon delivery data, BDA data and computer diagnostics are also resident in the MSU.

The computers are loaded through the data entry unit (DEU). A self-contained four channel cassette data cartridge is used to input the data at the OSO station. The OFS tape and mission data tape (with all the destinations, checkpoints, targets and timing on it) are loaded in the computer and then the data cartridges are carried on the flight in case a reload is necessary. Alternate mission data tapes may also be carried.

The OSO loads and "talks" to the computer through the integrated keyboard (IKB) (Fig 2). Using the IKB and its associated CRT display, mission data can be reviewed, manually entered, or changed; inertial unit startup modes can be selected and initial conditions data entered; auxiliary navigation programs such as the airborne instrument landing approach (AILA), course intercepts, or altitude calibrations can be initialized; and ACU memory locations can be displayed. In addition, through backup modes, almost any switch on the nav panel or the stores management subsystem (SMS) panel can be duplicated via the IKB. Using IKB backup, navigation modes can be selected, destinations can be called up and flown to, and the radar cross hairs can be laid on checkpoints. Offset selection, weapon arming, bomb door operation and many other tasks can also be done through the IKB if a panel should fail. It's another example of the fail operational philosophy.

The other major parts of the ACUC are the units that provide the interface with the various navigation sensors and with other aircraft subsytems. Each unit accepts signals in whatever format the sensor provides, converts the signal to a serial digital format, passes it on to the ACUs, reformats the results such as control or stabilization data and returns it to the sensor.

The links between the ACUC and other aircraft systems are also shown in Figure 1. The station logic units (SLU) are a sort of buffer/computer which provide information to the SMS. The SMS keeps track of the weapons on board, monitors weapon status, rotates the launcher to put the correct weapon to be released in the down position, provides weight data to the center-of-gravity computer, and generally handles all the weapon management. The central integrated test system (CITS) provides ground readiness testing, inflight failure detection, and fault isolation of aircraft systems and components. CITS monitors in detail almost all significant aircraft systems from air-conditioning to wing sweep; avionics from Doppler to the VSD; and radios from the ADF to the UHF. It displays fault data to the crew on an alpha numeric display and prints out the malfunctioning mode or specific LRU for ground maintenance.

The electrical multiplex (EMUX) provides the information and control data link with many aircraft systems and the logic processing for electrical power control. It manages the electrical load so that during engine start or in case of a generator failure, the generators are not overloaded and essential systems remain powered.

The diagram in Figure 1 is really oversimplified. Each arrow represents many lines of communication but, from an aircraft wiring standpoint, the few lines are representative because most of the signals are transmitted via the AMUX. The signals and commands are carried in serial digital form on these redundant data links. Information is continually flowing along the AMUX lines between the ACUs and the other units. When a component needs some information it can pick the data out of the stream as it goes by. The AMUX (and the EMUX) reduces the amount of point-to-point hard wiring which saves weight and reduces the vulnerability to damage.

For all its complexity and abundance of acronyms, the navigation and bombing system is not difficult to control and monitor. The computer mechanization is excellent, with most routine and time-consuming tasks being done for the OSO automatically. The ACU selects the best navigation mode (pure inertial, Doppler/inertial, etc.) automatically or the OSO can manually select a particular mode. Destinations and targets are stored in the computer and are automatically sequenced throughout the flight. The OSO's task is really to monitor the progress of the mission, to monitor the equipment, to make sure where the aircraft is going when it sequences, and to locate targets on the FLR with FLIR. The OSO has the time he needs to concentrate on the radar tasks of finding fixpoints and targets. This is especially important because the navigation mechanization includes a Kalman filter. The Kalman filter

Avionics Control Unit - Controls and Indicators.

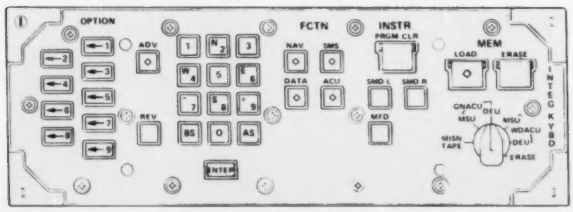


Figure 2

Inertial Navigation System - Controls and Indicators.

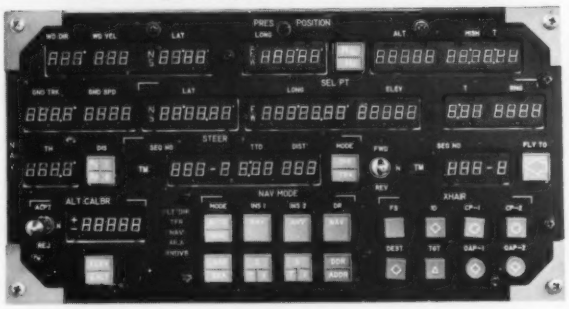


Figure 3

estimates the error sources in the IMU, Doppler and central air data computer (CADC) inputs, computes weighting factors based on the error estimates, and applies the weighting factors to the position computations. When the OSO takes a fix, he enters into the Kalman filter his estimate of the quality of the fix to help in weighing its importance. With this mechanization, not many fixes need to be taken after the IMUs are aligned, but the fixes that are taken must be accurate and should be treated almost like a bomb run.

Navigation data for the OSO is displayed on the nav panel (Fig 3). This includes the B-1's current position, true heading and ground speed, wind, destination sequence number, coordinates of the current checkpoint, either altitude above sea level or absolute altitude, and the current navigation mode. The OSO controls the navigation here also, selecting the navigation mode or letting the computer do it, making altitude calibrations, laying the cross hairs on checkpoints, offsets or targets, and selecting the destination. The nav panel is the prime source of data, but additional navigation information and flight parameters are available on the IKB CRT. For example, the OSO can call up on the CRT the ETE and ETA to a destination. The ETA and ETE are computed both along the preplanned track and directly to the point. On the first flight, it turned out that most of the information on the nav panel and the backup modes available through the IKB would be required.

We climbed aboard the B-1 at 1000. The computers were on and the IMUs were aligned and ready to go. After preflight and some ground checks, the engines were started and we switched over to internal power. Pure inertial navigation with IMU-1 as the prime data source was selected prior to taxi.

Takeoff was at 1127. The acceleration, with the four GE F-101 engines in max augmentation (our word for afterburner) was more like that of a fighter than any big airplane I have ever flown in. Takeoff roll was short and the B-1 lifted off almost abeam a crowd of Rockwell workers who had helped build it.

The first flight was scheduled to take 4.5 hours. Typical first flight tasks were planned, such as cycling the landing gear, flaps and slats, sweeping the wings, performing airspeed calibrations in the cruise configurations with a T-38 pacer and in the landing configuration with a T-37 pacer, making flight controls and handling qualities checks, and checking out the basic modes and tasks of the offensive avionics system.

After takeoff, the FLR was checked out first. Cross hair control by the computer and the tracking handle, manual and automatic tilt, scope orientation, and various radar modes and ranges were all operated. Some ACU functions were checked next. The cross hairs were moved to check points and destinations. Targets were called up to see that the system went into bomb and gave the correct indications. Destinations were selected and the steering commands were checked on the pilot's VSD and HSI. The computers were operating just as they had on the ground at the Boeing test facility.

About half an hour after takeoff the gear was cycled once to check its inflight operation and the pilot started to retract the flaps and slats. As they came up, a power transient blanked the nav panel for a short time, caused IMU-1 to shut down, and disconnected the MSU. The GNACU automatically switched the prime data source to IMU-2 and kept on working.

In flight test, you find that when a problem develops, even though you may have some idea of what happened and what to do, you first talk to the engineers on the ground. In this case, I talked to Bob Moore of Boeing who had been involved with the software and this equipment since it was first powered up in Seattle. I checked some computer memory locations for him and it was decided to cycle the WDACU so that the MSU would hook up again with the ACUs. Without the MSU we had to wait until the DEU tape rolled to a

B-1 Takeoff.

specific memory location before we would get a task performed. I cycled the WDACU and the MSU hooked up normally.

The nav panel was displaying information again but the switches were inoperative, so I began to operate them in the back-up mode. I found it was straightforward and easy to use, an early data point we hadn't planned on. It was a bit slower than just operating a switch or a button, but as I used it more, I found that a switch just became a series of punches on the IKB option buttons. For example, an altitude calibration became a 4-3 to set up; a 7-4-1 to do the calibration; and a 2 to accept it. Entering a fix became a 7-6-4. It all worked just as it should.

I turned IMU-1 back on to attempt air alignment. The B-1 was held straight-and-level through the initial course leveling. No heat or leveling timers were overridden and the fine align light came on after about half an hour. IMU-1 was placed in the Doppler inertial mode for the rest of the alignment. Meanwhile, IMU-2 was still in the pure inertial mode; an altitude calibration was accomplished and the pilots continued their inflight checks.

A simulated weapons release was scheduled while we were still at altitude. FULL SIM was selected in the computers, simulated B-43 weapons were turned on and armed, and the target was sequenced up as the destination. On the bomb run, the cross hairs movement, steering commands to the pilots, time-to-go indications, and OAP selection were all as they should have been. The tone came on automatically at 10 seconds to go, the bomb doors indicated open, and the release signal was indicated at the tone cut. All equipment operated perfectly the first time and has ever since, except for one tone malfunction.

Some airspeed calibrations and the high altitude TFR checks were made next. The TFR checks included a comparison of the vertical velocities on the two IMUs. The velocities agreed with 0.7 ft/sec., even though the fine align light was still on for IMU-1. A manual TFR descent and three manual TFR runs were made over Haystack Butte, an isolated hill on the Edwards test range, at 1,000 feet and on soft, medium, and hard ride. The profile of our flight path over the hill was plotted in real time in the control room at Edwards. It was then compared with the predicted aircraft path to see if the TFR was working properly. This method was used on subsequent flights for our TFR checkout as we progressed to automatic terrain following, lower altitudes, and higher speeds.

At 1530 the first fix update was put into the system. The Kalman filters for both IMUs accepted the fix and, thereafter, the error stayed very low. At 1535 IMU-2 was placed in the Doppler inertial mode for the rest of the flight.

We climbed back to altitude after the TFR runs for some acoustic and vibration checks and some airspeed calibrations. The FLIR pod was lowered and the forward weapon bay doors were cycled part and full open. Then airspeed calibrations were made with the B-1 in the landing configuration and we prepared to land.

Final approach was an ILS but I set up for an AILA backup and checked out our planned AILA offset. The B-1's APQ-144 radar has a range setting of 2.5 NM and the detail visible in the scope at that short range is greater than I have ever seen on an airborne radar. It makes placing the radar cross hairs for an AILA very easy and precise.

We landed after 4.9 hours. An IMU drift run, electromagnetic interference checks of the HF radio, and some engine runs were accomplished at the end of the runway. We taxied in, parked, and shut down at 1752.

It had been an excellent first flight. The first time off the ground the computers, IMUs, radar, Doppler, FLIR, radar altimeters and CADC had all worked well together. We had done normal navigation in all modes, aligned an IMU, taken a fix, made a bomb run, and flown TFR. The system had performed as designed when the power transient occurred and the backup control modes had proven to be satisfactory. Avionics test programs have been notorious for having a frustrating beginning, especially where extensive software development is involved. I have seen new equipment that checked out on the ground, but then took five flights to work in the air satisfactorily. This was not true with the B-1 avionics. All the careful simulation and check out prior to flight had paid off.

The program has continued to go well since that first flight. The power transient occurred once more and then was fixed by making a software

B-1 Low Level Flight in Glen Canyon.

change in the EMUX. The auto pilot has been checked out, coupled to the navigation system, and used to steer the B-1 on both bomb runs and navigation legs. Manual AILAs have been accomplished. The aircraft has flown supersonically and all basic systems have been checked.

Navigation accuracy has been tested in several modes. Navigation legs were flown in the pure inertial mode after a ground alignment, in the Doppler-inertial mode after a ground alignment, and in the Doppler-inertial mode after an air alignment. The navigation legs were flown on approximately cardinal headings, lasted two to three hours, included some TFR and over water flight, and did not include any position updates after the alignment was complete. The B-1 was ground radar tracked throughout and the results have been very good with IMU drift rate values coming in well within the specifications. The Kalman filter mechanization has been keeping the drift rate very low, especially when given some fixes early in the mission (such as is the case with an air alignment) to help determine the error coefficients.

The TFR envelope has been expanded step by step on the Edwards range. The B-1 has completed on-site TFR testing down to 200 feet and Mach .85. We have begun to fly off-site routes using OB-20, Holbrook, Arizona; VFR route TR 368 from point E, south of George AFB, to point I, just north of the Salton Sea; and TR 354 (modified), from Paso Robles to the Edwards AFB range. These are good, challenging low level routes. OB-20 and TR-354 can be terminated with a simulated weapon release. One of the most impressive sights I've ever seen in the air was on OB-20, watching from an F-111 chase while the B-1 flew deep into Glen Canyon on automatic TFR. At one point, the B-1 descended alongside a vertical wall that ran parallel to track until it was more than 200 feet below the rim.

Simulated weapon releases have been made and ground scored optically at both high and low altitude. The low releases were made automatically at 400 feet and M .85. The simulated SRAM launches have all been made manually so that we can control the launch point and evaluate how accurately the SRAM would have flown. The scores are very good so far, averaging less than the specification. That means the avionics are working properly and can accurately compute a release point. The next step will be to release actual shapes and measure the aircraft flow field and ejector effects. Those effects will then be included in the computer calculations and more shapes will be dropped to verify the CEP.

All has not gone perfectly, but that is why we flight test. Most of the avionics problems have just been quirks in the original software mechanizations and have been fairly easy to correct. For example, the radar cross hairs are normally stabilized to the ground track. But, during preflight when the ground speed was zero, the track varied, making the cross hairs unstable. This made it difficult to check out the FLR. The problem was solved by a software patch that changed the stabilization reference to true heading when the aircraft was on the ground. Some changes remain to be made and they are being worked as a joint effort between the B-1 SPO, SAC, Boeing, Rockwell, and the Joint Test Force here at Edwards AFB.

In summary, the B-1 avionics have performed extremely well. The fail-operational redundancy built into the design has paid off already in flight test in terms of not losing data or flights due to system malfunctions. In a briefing at SAC, Major Fred Black mentioned that even though we are in a flight test development program, we have not had any inflight avionics failures that would have caused an abort on an actual EWO mission. That is truly remarkable for a test program!

Future flight tests are already being planned. Longer navigation legs of various types, more simulated bomb runs, actual weapon releases, and live SRAM launches will all be accomplished. I'm looking forward to all of it. Flight test is the most rewarding and enjoyable work I've ever experienced. The B-1 in particular is a pleasure to operate, with a logical and straightforward mechanization. The B-1 OSO will be able to navigate, bomb, and monitor three bomb bays full of weapons with no greater workload than is required by comparable aircraft. The B-1 should provide SAC with a great capability for a long time.

Lt Col Brotnov entered the Air Force in May 1958, and completed navigator training in 1959. For the next four years he flew B-47s, including two years on the Stan Eval crew. After obtaining his master's degree in Aerospace Engineering from AFIT, he was assigned to the USAF Academy. There he served as Director of the Planetarium in addition to teaching duties. In 1971-72, he had an EC-47 assignment in Vietnam. He is presently assigned to AFFTC, Edwards AFB, on the F-4E Test Team.

Captain Gary A. VOELLGER
523 TFS
Cannon AFB NM

Low level penetration of enemy territory has proven to be a particularly viable tactic in combat operations. It is further enhanced during night and/or weather conditions. But as with any other tactic, it has certain intrinsic disadvantages. The margin for error is greatly reduced due to your proximity to the ground and workloads are magnified as a result of the time compression inherent in short navigation legs. However, these shortcomings may be overcome by an aircrew thoroughly versed in low level operations and prepared for the associated contingencies.

Each leg of a low level may almost be treated as a separate entity; the turn points acting as transitions to join the legs into a complete route. For the sake of this article, I'll basically address just one low level leg. Keep in mind that the techniques proposed are applicable to almost any low level navigation leg.

Present Position and Dead Reckoning

Before embarking upon navigational legs, particularly if at low level, you are dependent upon a known point of departure. Without this prerequisite, all attempts at navigation would be mere presumption with the results being appropriately indeterminate. The remainder of this article will proceed with the assumption that we are progressing from a known present position. Dead reckoning is the primary means of navigation. All of the visual, mechanical and electronic aids provided are merely supplemental to DR. Many a check ride has been busted and many an aircrew has been temporarily disoriented (lost) simply because they either didn't use DR or they accepted erroneous data from malfunctioning equipment despite a contradictory DR position.

The Running DR

A running DR is a technique used by most experienced crews on a high speed low level where the actual plotting of a DR position on a map is not realistic in view of the inherent short legs and high speeds. The technique involved is to project from a known position to another position that is immediately identifiable either visually or electronically. As the selected landmark/radar return is approached, a new identifiable position is projected. The technique continues throughout the low level, thus the name "running DR".

Timing

For DR purposes most aircrews either maintain a "leg time" or use the continuous timing

LOW LEVEL TECH

technique. "Leg times" begin at each turn point; the clock is hacked and the leg is flown close to preplanned ground speed and preplanned ground track. Using "continuous timing" the crew may either start the timing at the beginning of the route and run a continuous ETA for each turnpoint, or use GMT/local time ETAs for each turnpoint. This technique, allowing for minor excursions, also requires flight along the preplanned ground track at the preplanned ground speed.

Correcting Timing

Should you arrive at one of your turnpoints early or late, the corrective action would appear obvious. If you are early, slow down; if late, accelerate. However, imprecise gross corrections have little positive value; therefore, you should have some ballpark estimate of how much speed change is required and for how long. Two generally applied mathematical methods are employed to arrive at reasonable estimates. The first technique is merely an application of the time-distance problem. It is most often applied in increments of whole minutes relative to a turnpoint/target. One simply divides the number of miles remaining by the time remaining until your ETA to get the miles per minute required. Multiply the miles per minute by 60 and you have the required ground speed.

Example:

Present time - 1240

ETA to turnpoint/target - 1244

Distance to turnpoint/target - 32 miles

$$\frac{\text{Distance remaining 32 miles}}{\text{Time remaining 4 minutes}} = 8$$

8 miles/minute x 60 = 480 knots ground speed.

The second technique, though somewhat more complicated, may be applied more generally. Given a specific timing deviation, increase/decrease your preplanned ground speed by 10% for ten times the time deviation. Confused? Here's a simple example:

You are 40 seconds late at point B. Your preplanned ground speed is 420 knots. To get back on time you would increase your groundspeed to 462 knots for 400 seconds (6 minutes 40 seconds).

Timing deviation - 40 seconds slow

10 x 40 = 400 seconds

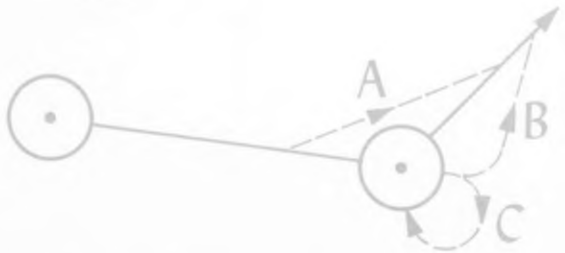
Ground speed = 420 knots =

42 knots (10%) = 462 knots

The variations on this formula are unlimited. (For example, you may change ground speed by 5% for 20 times the time deviation. Another variation is to increase ground speed by 10% for 10 minutes to gain/lose one minute.)

However, before you make any timing corrections, KNOW FOR CERTAIN WHETHER YOU ARE EARLY OR LATE AND CORRECT PROPERLY. It does you little good to flawlessly compute corrections and then apply them in reverse. Don't be too proud to write down the numbers if the slightest confusion exists. There is another often overlooked method for correcting timing, shortening or lengthening the route. Each turnpoint providing a heading change can be the basis for a timing triangle. If on a Low Altitude Training Route or OB route, be sure to remain within the route corridor and adhere to airspeed restrictions.

Example:



Deviation A - shortens route

Deviation B - lengthens route

Deviation C - a drastic, but applicable, technique to lengthen route.

Turn Point Techniques

Turn point techniques can be generally grouped into pre and post turnpoint categories. Approaching a turnpoint (approximately 1 minute out) the following should be noted.

"T.D. Hads"

T = Time - Note any deviations to preplanned timing for subsequent correction.

D = Direction of Turn - left/right/straight ahead.

H = Heading - Note how many degrees of turn will be required to aid in estimating how long you will be in the turn. Remember the heading for your initial rollout.

A = Altitude - Note any impending climbs or descents. Additionally, note any change in the MEA. (If your aircraft has the capability to "bug" the MEA, a good technique is to mark it prior to the turnpoint for higher MEAs and subsequent to the turnpoint for lower MEAs.

D = Distance/Time - For inertial equipped aircraft, this is the other half of the DR data

NIQUES

required for an initial appraisal of INS steering. It also keys the crew as to the pacing that will be required for the next leg.

S = Speed - This acts as a reminder to maintain current conditions or accelerate/decelerate as required for the next leg.

As an aid to remembering these steps you might use the acronym "T.D. HADS".

The Turn

You will probably find as many philosophies on what to do during turns as there are aircrews. Given this platform, I would like to expound my personal views. THE TURN REQUIRES 100% OF YOUR ATTENTION. You are maneuvering the aircraft, consequently you are considerably more susceptible to the most effective anti-aircraft weapon ever developed, "the ground". Even Terrain Following Radar (TFR) equipped aircraft face considerable problems such as drift rate, lead-into-turn, and field of view. Once the turn is completed you can resume the navigation problem at hand.

Post Turnpoint Procedures

With a tremendous sigh of relief (particularly at night) you roll wings level, only to face another low level leg. Navigation wise, the most pressing matter is a TIMS check. This exceptionally effective technique has been widely used and warrants adoption.

"T. I. M. S."

T = Time - Note the time of arrival over a known point. (It does not necessarily have to be the turnpoint.) Once given the present position, a DR position may be projected; given the time, an ETA to that DR position may also be computed.

I = Inertial - Compare the inertial present position with the coordinates of the known position. Then compare the inertial range and bearing to the next turn point/target with your preplanned data.

M = Map - Beginning with your known position on the map, identify the surrounding terrain and cultural features. Then project the prominent visual features to be used along the leg in maintaining course and identifying the turnpoint/target.

S = Scope - Using the known position as a reference, identify significant radar returns and use them in the same manner as the visual cues.

Pacing

Pacing is the command-approved term used by ATC. Preflight planning of each leg should include the anticipated timing and execution points applicable to mission essential tasks. Remember that the key to pacing is the establishment of priorities. As experience is increased, you are generally able to progress along the continuum including more elements in your pacing, thus enhancing mission capability. Priorities may also change. Retain the flexibility to recognize this fact and alter your thinking accordingly. Only perform tasks for which you have capabilities, and then in order of priority.

Crew Coordination

For multi-place aircraft, crew coordination is a vitally important consideration during low level operations. Just as pacing is the key to individual performance, crew coordination is the key to mutually generated performance. Communication is the most essential element to good crew coordination, both in the aircraft and on the ground. Each crew member must be thoroughly familiar with the mission as well as the inter-relationship of each other's tasks relative to the overall mission objectives. Each member of the crew must insure that all crewmembers are aware of what is required by and from each other. The most effective way to handle this is to establish on the ground just what mission essential information will be required, why and when. As a result, in-flight communication effectiveness is maximized. Each crew, because of the varying personalities involved, will require personalized crew coordination. The style employed is relatively insignificant, so long as "on time, on target" reliability is maximized.

Mid-Leg Techniques

After surviving the trauma of the turnpoint and confirming your navigational prowess, you should have sufficient opportunity for equipment checks. A good "ops check" is an outstanding insurance policy, and the price is right. This is also a good time to cross-check your flight instruments and evaluate the performance of aircraft equipment.

The IP

An IP is like any other turnpoint with the exception that it is the precursor to the bomb run. All of the previously discussed techniques generally apply. However, we must now add a bomb run checklist. Actual performance of the checklist will be dictated by existing conditions, but it should normally be verified complete shortly after the IP.

The Target

The target run also has many features in common with other low level legs. However, this is one time where absolute precision is mandatory. There is no sense in flying a perfect low level only to drop a gross bomb or go through dry. During the target run you have pretty much committed yourself to a TOT block, and timing takes a lower priority. Of immediate concern is target acquisition, and verification that the weapons release switchology is correct. The bomb run itself has been the subject of many other articles so I'll press on with this cursory treatment leaving the details to the experts.

Black Line Fever

Black line fever is the tendency on the part of many aircrew members to fly the centerline of a preplanned low level. The name comes in part from following the black line drawn on the map and in part from the line of hydraulic fluid and oil drippings found down the centerline of frequently flown low levels. Black line fever produces boredom in the cockpit, and, more importantly, results in negative training for combat conditions. Black line fever also applies to turnpoints. There is no mystical power that prevents progression to the next leg of a low level for those aircraft which do not penetrate the circle around the turnpoint adorning your map. *Note: This does not apply to targets, and is not to be used as an excuse for bad RLDS.*

Post Release

Don't Quit! It is not over. Continue to operate with the same tools that got you this far. Post release let down often leads to confusion and chaos in the cockpit. With the addition of post release checklist items, the leg after the target should be flown much like any other low level leg. Don't forget to cover it in your briefing.

Some Final Thoughts

There are certain disadvantages inherent in low level operation that should be mentioned. First, the useful range of radar, due to its line of sight properties, may be severely limited. Make sure that your preflight planning takes this into consideration. Second, be aware of the birdstrike threat at low altitude. During daylight conditions, it is a good technique to keep as many eyes as possible "out of the cockpit." This technique also aids in avoiding man-made birds. Also, remember to keep your visors down and oxygen mask on. Third, your operating altitude should be only as low as required by the mission. In combat, it is an unnecessary risk to go any lower than the threat dictates. In the training arena, it is necessary to exercise combat contingencies. However, altitudes should be dictated by training necessity with an awareness of the associated dangers. If the same training can be garnered at 1000 feet as at 400 feet, there is no sense in exposing yourself at the lower altitude.

Recap

Low level navigation is an extremely demanding and complex phase of flight. You are given little opportunity to recover if you get behind the aircraft, and the Grim Reaper stands in judgment of your every move. Consequently, good judgment and the need for self-preservation dictate a thorough comprehension of low level operations. You should be aware that the techniques proposed in this article merely constitute a generalized foundation from which you can depart in formulating your own low level techniques. Nevertheless, there are some salient points that can be repeated.

1. DR IS THE PRIMARY MEANS OF NAVIGATION.
2. HAVE AN ESTIMATE OF THE AMOUNT AND DURATION OF GROUND SPEED ADJUSTMENTS FOR TIMING DEVIATION CORRECTIONS.
3. INSURE THAT YOU APPLY TIMING CORRECTIONS IN THE PROPER MANNER.
4. HAVE A SPECIFIC TURNPOINT TECHNIQUE AND USE IT. (T.D. HADS AND TIMS ARE TWO GOOD METHODS)
5. DON'T LET DOWN AFTER THE TARGET.
6. AVOID STRICT ADHERENCE TO THE ROUTE CENTERLINE.
7. PACING AND CREW COORDINATION ARE KEY ELEMENTS IN SUCCESSFUL LOW LEVEL OPERATIONS.
8. DON'T TAKE UNNECESSARY RISKS.
9. ESTABLISH PRIORITIES AND ADHERE TO THEM.

Captain Gary A. Voellger is a 1969 UNT graduate. His initial assignment was to F-4 training at MacDill AFB, Florida followed by a USAF tour at RAF Bentwaters, England. In 1972 Capt Voellger attended UPT at Laredo AFB, Texas followed by assignments to the F-111A at Nellis AFB, Nevada and Takhli RTAFB, Thailand. He is presently assigned as an F-111D Aircraft Commander at Cannon AFB, New Mexico. The majority of Capt Voellger's flying experience has been in the low level strike role.

Fine tuning your INS

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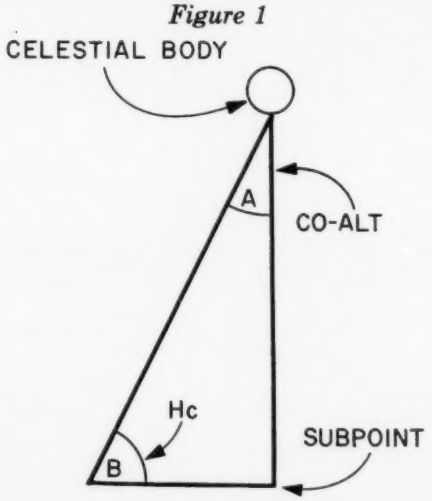
Those of us fortunate enough to have an Inertial Navigation System (INS) aboard our aircraft have probably wondered if this "machine of the seventies" is capable of doing more than the "Dash-1" says it can, especially if we were old C-141 navigators and had a computer that was able to "pre-comp" for us. Of course, if you fly on an aircraft that has more than one INS you may think that the thought of doing celestial is a little ridiculous. For those of you whose aircraft has only one such unit, or for those who feel bored watching the present position (PP) coordinates pass by, we have determined a way to "pre-comp" with the INS. And for those of you who have taken-off from "home station" and forgotten your C-5 Airfield Diagram Plates which provide that useful information for "tuning" the little "wonder of electronics", or if your aircraft has landed at a field not depicted on the diagrams, we have devised a graph that will determine aircraft ramp position, accurate to within two-tenths of a minute of arc.

Celestial With The INS

The INS can be used for computing the Hc of a celestial body. Before we describe the steps necessary, let us first discuss a few concepts of the Astronomical Triangle and their relation to the INS.

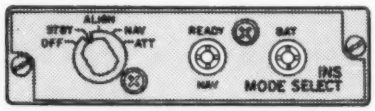
Normally, to calculate the Hc of a particular celestial body, we determine the LHA of the body by subtracting/adding the longitude of the assumed position from/to the GHA of the body, entering the appropriate volume, and extracting an Hc. The Hc is then corrected for any differences in declination, if required. The result is Angle B in Figure 1. Angle A in Figure 1 (Co-altitude or CO-ALT) is the compliment of the Hc (90-00 - Hc = CO-ALT). The CO-ALT gives the distance in nautical miles between the subpoint of the body and the assumed position when multiplied by 60. The sum of the Hc and the CO-ALT equals 90 degrees, or 5400 nautical miles (60 nm x 90-00). (Paragraph "Observed Altitude", pg 11-18, AFM 51-40, 1 July 1973, discusses this relationship.) Therefore, it would be possible to determine the Hc if we knew the subpoint and the assumed position. This would be impractical though, since we would have to plot these points

Figure 1

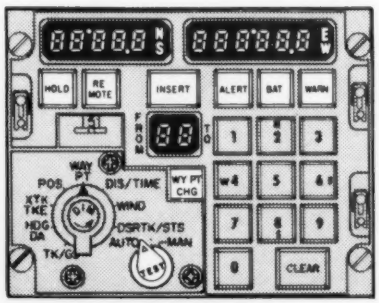


and we do not carry charts and plotters large enough to accomplish this task. (See Chapter 14, pgs 14-1 and 14-2, AFM 51-40, 1 July 1973, for discussion of the subpoint method.) This matter has been simplified through the use of LHAs and their relationship to the Hc and the declination of the celestial body. If we had a computer, however, we could solve this problem using only the Air Almanac. For those navigators whose aircraft are equipped with an INS, they can do just that.

CONTROL UNITS



MODE SELECTOR



CONTROL/DISPLAY

Figure 2

By storing the GHA and Dec of the celestial body in an INS waypoint, the exact distance from the INS PP to the body's subpoint may be computed. This distance is then subtracted from 5400 nm, the remainder is the Hc in nautical miles. Simply divide this by 60 and the result is the Hc in degrees and minutes. The Hc can then be compared to the Ho and the intercept determined. Normal corrections are applied to the Hs to determine Ho; coriolis and rhumb line, precession and nutation (as required) are applied to the INS PP at "fix time." Since the INS computes everything in relation to its present position, the PP is the assumed position. The intercept is plotted in the normal way using the ZN (true azimuth) which is obtained from the desired track read-out on the INS. The intercept that is obtained should be very small or zero. Any difference between the INS PP and the LOP (assuming no sextant/shooting error) would reflect an error in the INS.

Note: Assuming no errors, maximum intercept would occur on course line LOPs and conversely, zero intercept would be found on speed line LOPs due to the effect of coriolis/ rhumb line. This would be an apparent error only. The intercept error of course line LOPs would be resolved in plotting. Speed line LOPs would probably not have to be plotted if the intercept were only a mile or two.

Suggested Procedures

All INS data display references are based on the CAROUSEL IV, Inertial Navigation System, made by Delco Electronics, General Motors Corporation, Milwaukee, Wisconsin. (Figure 2) All INS units should offer the same information, but the navigator may have to vary the suggested procedures depending on the program logic of the data display portion of his particular INS.

Note: For the discussion of these procedures, it is assumed that the reader is familiar with the basic operation of an INS.

1. About 10 minutes prior to "fix time" insert the proper GHA and Dec of the body into any waypoint (e.g. Waypoint 3).

e.g. GHA of Sun = 144-44.7
Dec = S 01-39.9

a. Dec is inserted into latitude keeping the same hemisphere: Insert 01-39.9S.

b. GHA is inserted as longitude. If less than 180, GHA is west longitude (144-44.7W). If greater than 180, subtract from 360 and insert as east longitude (e.g. GHA: 185-05.2=174-54.8E). You have now inserted the subpoint of the sun.

2. Prior to your fix/MPP (determine approximate Hc):

a. Press waypoint change (WYPT CHG), 0 to waypoint of the sun (e.g. 0-3), (fig 3) and insert.

b. Turn to desired track/status (DSRTK/STS); this gives you the true course from the coordinates stored in waypoint 0 to the subpoint of the celestial body, or the ZN.

c. Switch to distance/time (DIS/TIME) and note distance read-out, e.g. 2200 nm (Distance from subpoint to INS PP [A, fig 3] equals CO-ALT of celestial body [B, fig 3] in nautical miles).

d. Subtract CO-ALT from 5400 nm and divide by 60 to determine approximate Hc. * (Angle C, fig 3). 5400 - 2200 = 3200

$$60\overline{)3200}\quad 53^{0} - 20'$$
$$\underline{300}$$
$$200$$
$$\underline{180}$$
$$20$$

* Assuming the INS to be accurate, this Hc should equal an approximate Hs for sighting the sextant.

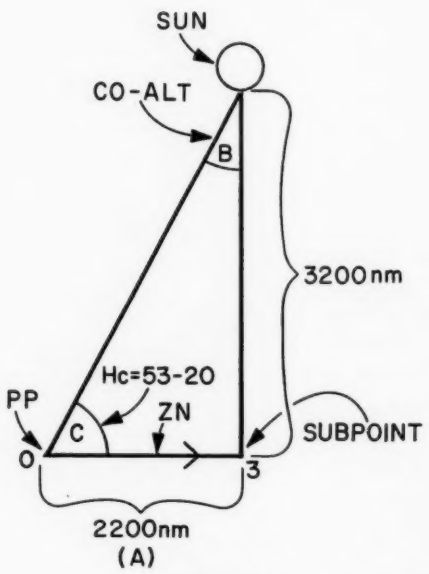


Figure 3

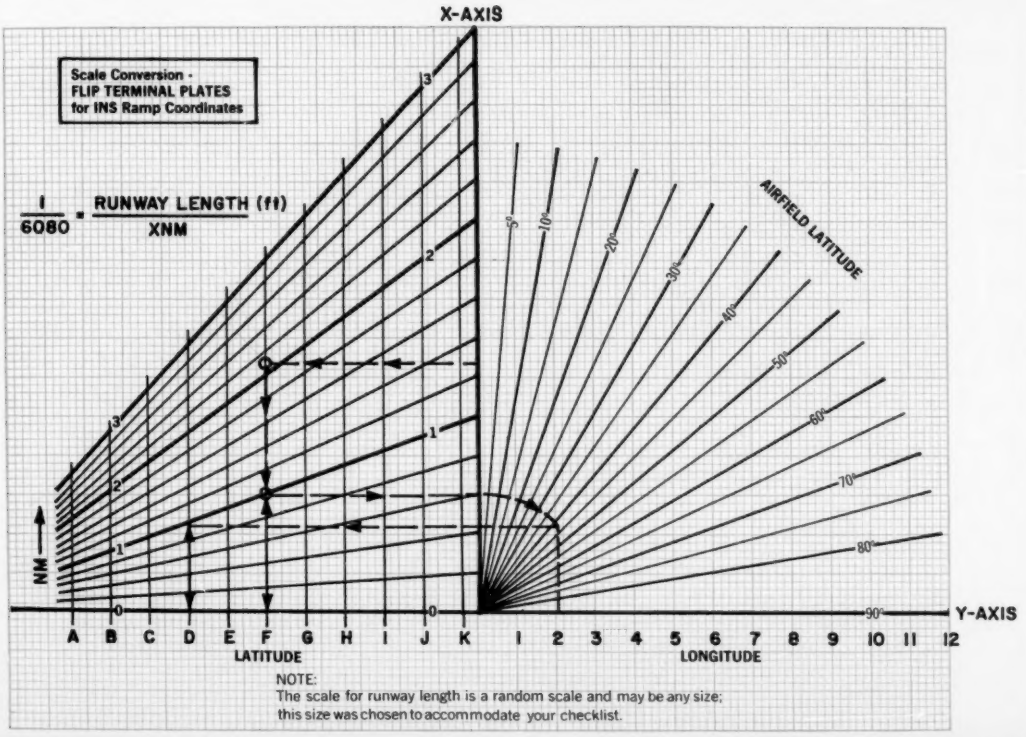
3. At Fix Time:
   a. Prior to starting the "shot":
      (1) Turn display knob to DIS/TIME.
      (2) Press WYPT CHG, 0 to waypoint of sun and insert - result is updated ZN of sun. (This ZN will be accurate enough for plotting your intercept.)
   b. At midtime press HOLD and note distance of subpoint.
   c. After "shot":
      (1) Turn to DSRTK/STS and obtain ZN of sun.
      (2) Turn to HD/DA (Heading/Drift Angle) and check true heading.
      (3) Turn to POS (Position) and record PP at "fix time"; depress HOLD key.
4. Computing Hc of sun:
   a. Solve for Hc as in Step 2.
   b. Compare Hc to Ho and solve in normal way (HO MO TO).
      (1) Do not forget to apply refraction, etc.
      (2) No motion adjust, shooting on time.
5. Plotting LOP:
   a. Assume position is the INS PP (Apply Coriolis/Rhumb Line; Precession and Nutation as required).
   b. Plot intercept using INS ZN.

This procedure is applicable to all celestial bodies; however, for stars this method will be more time consuming. Using this method for single bodies is simple and it provides an easy check of the INS. As stated above, if the INS is working properly, the intercept obtained will be small.

Determination of Ramp Coordinates

The C-5 Airfield Diagrams used for determining aircraft ramp position Inertial Navigation System alignment coordinates cover only airfields most frequented by the Department of Defense INS equipped aircraft. There are times when these aircraft land at fields not depicted on charts and the navigator requires a method of determining

Figure 4


X-AXIS
Scale Conversion -
FLIP TERMINAL PLATES
for INS Ramp Coordinates
1/6080 = RUNWAY LENGTH (ft) / XNM
AIRFIELD LATITUDE
NM
Y-AXIS
A B C D E F G H I J K
LATITUDE
1 2 3 4 5 6 7 8 9 10 11 12
LONGITUDE
NOTE:
The scale for runway length is a random scale and may be any size;
this size was chosen to accommodate your checklist.

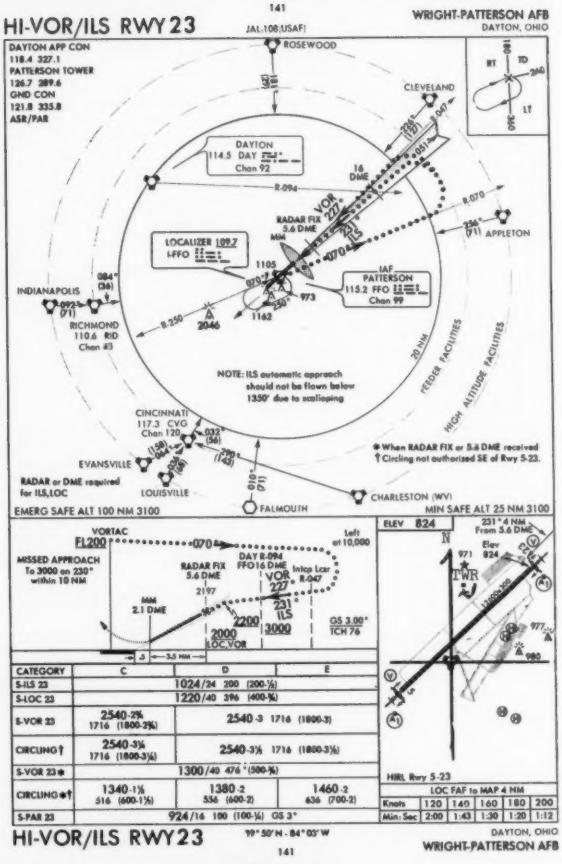


Figure 5

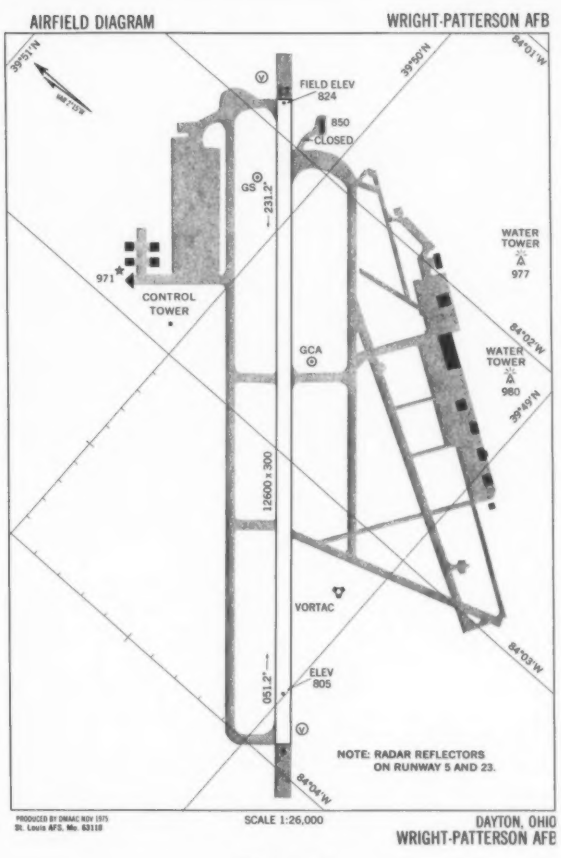


Figure 6

the ramp coordinates. The method to be described uses the graph in figure 4 in conjunction with the airfield box depicted on all approach plates and is accurate to within two-tenths of a minute of arc.

To determine the aircraft ramp coordinates the navigator need only know the coordinates of one of the radio aid facilities normally shown in the airfield box of the approach plate. These coordinates can be obtained from the appropriate Enroute Supplement. A procedure will be discussed later for determining ramp coordinates if the radio aid is located outside the airfield depiction.

Fortunately most airfields have the serving radio facility within the confines of the box on the approach plate. For those fields, construction of north - south, east - west reference lines can easily be accomplished. The border of the box is referenced to true north; therefore, the navigator need simply parallel the border of the box in constructing a N/S, E/W line through the center of the radio facility serving the field. For our example we will use Wright-Patterson Air Force Base, Ohio, (WPAFB). It has a C-5 Airfield Diagram and, therefore, can be used to check the accuracy of this method.

Assume that we want to determine the coordinates of the control tower (shown on both the approach plate, figure 5, and the C-5 Airfield Diagram, figure 6). For our point of origin we will use the VORTAC depicted on the airfield diagram. Its coordinates are 39° 49'05"N and 84° 03' 17"W(39-49.1N and 84-03.3W).

1. Construct a N/S - E/W line through the VORTAC site depicted on the (HI-VOR/ILS RWY 23) approach plate, figure 5.

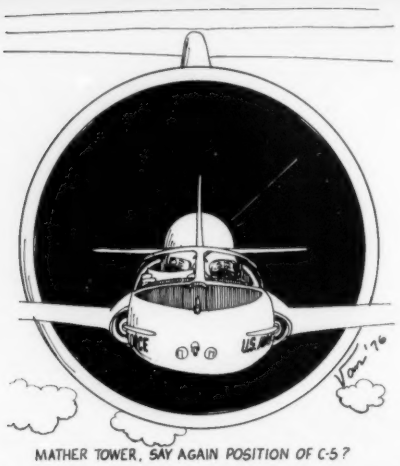
2. Convert the runway length (12,600') in feet to nautical miles using this equation:

$$\frac{1}{6080} = \frac{X(\text{RWY length in NM})}{\text{RWY length in feet}} \quad \frac{1}{6080} = \frac{2.1\ \text{NM}}{12{,}600'}$$

3. Span-off the length of the runway depicted with a pair of dividers (do not include the overrun).

4. Place the dividers on the vertical axis (X - axis) of the Latitude Conversion plate and proceed to the left until the "spanned" distance equals runway length. Close dividers until distance equals one nautical mile. Note the reference point for future use (Point F).

5. Keeping the dividers as they are, proceed to the Longitude Conversion Graph and place one tip of the dividers on the point of origin and the other on the X - axis, 0 degree latitude line.



MATHER TOWER, SAY AGAIN POSITION OF C-5?

Guest Cartoonist: **Major Stanley E. VAN HORN**

6. Rotate the dividers clockwise until the tip intersects the proper latitude line for the airfield (40 degrees for WPAFB). The vertical distance from this point to the Y - axis (90 degree latitude line) represents one minute of longitude at 40 degrees latitude.

7. Next, span the vertical distance from the 40 degree latitude line to the Y - axis. Using the vertical axis of the Latitude Conversion plate, proceed to the left until the "spanned distance" equals one minute of longitude on the Latitude Conversion plate. Note the reference point (Point D).

8. Return to the airfield diagram on the approach plate and measure the vertical displacement between the E/W line constructed through the VORTAC site and the control tower. Return to the latitude reference point (Point F) on the Latitude Conversion plate and determine the tenths of minutes of latitude distance between the VORTAC site and the Control Tower (0.9).

9. Measure the lateral displacement between the N/S line and the Control Tower. Use the Latitude Conversion plate to convert this distance to tenths of degrees of longitude using the reference Point D (0.3).

10. To determine the exact latitude and longitude of the Control Tower you simply add or subtract the tenths of degrees of latitude and longitude determined in steps 8 and 9 to the coordinates of the VORTAC site. Since the tower is north and east of the VORTAC, you add latitude and subtract longitude.

VORTAC COORDINATES:	39-49.1 N	84-03.3W
	+0.9	-0.3
Control Twr Coord =	39-50.0 N	84-03.0W

11. From the airfield box we obtain coordinates of 39-50.0N; 84-03.0W. These can be compared to the coordinates extracted from the C-5 Airfield Diagram plate: 39-50.1N; 84-02.9W (to the nearest tenth of a minute).

Some fields may not have radio facilities collocated at the field they serve. Normally, these facilities are referenced at the end of one of the runways in distance and magnetic bearing. When this situation arises, attach a piece of blank paper to the end of the runway referenced in the enroute supplement or on the approach plate and construct lines of latitude and longitude using the steps outlined above to determine the values of the latitude and longitude at your position, i.e., if the approach plate or the enroute supplement stated that it was 2.6 nm on a bearing of 240 degrees to the edge of runway 23 from the radio facility, construct a line from the approach edge of runway 23, 2.6 nm in length using the scale of the depicted runway in the reciprocal direction. Mark the spot on the paper and construct a N/S - E/W line sufficiently long enough to allow the scaling of two to three minutes of latitude and longitude in the direction of the airfield area. Annotate these lines and determine the coordinates of the parking spot.

The INS is a versatile piece of electronic equipment, but its success depends upon the information provided it and how it is used. Hopefully, this article has added to your knowledge of the INS and its capabilities.

Having an INS is "nice"; it is our answer to the autopilot. But remember, autopilots do malfunction; therefore, if you have only one INS, be ready for the worst. Sometimes they may malfunction with no warning or indication. Do not forget, if your INS Battery Light illuminates, you have about 20 minutes to find out where you are!

Lt Col Wallace E. Beebe was a B-29 Navigator during WW II. After the war, he attended Ohio State University and received a Bachelor of Science degree in Aeronautical Engineering in 1951. He was recalled to active duty during the Korean war and flew both the KB-29 and KC-97. He has had assignments testing new weapon systems and served as a staff assistant to the APOLLO Program Director in NASA's Office of Manned Space Flight. He is the Wing Navigator for the 4950th Test Wing.

Captain Gerald R. J. Heuer entered the Air Force in 1964 after graduating from the University of Michigan. After UNT at James Connally AFB, he crisscrossed the US and SEA flying various aircraft. While at Patrick AFB, his article on the EC-135N appeared in the Fall 1975 Issue of THE NAVIGATOR. In December 1975, he transferred to Wright-Patterson AFB with the EC-135s and entered AFIT in the fall of 1976.

Celestial COMPETENCE

Captain Joseph R. HAMLIN
USAF Test Plt Sch, Class 76B
Edwards AFB CA

One of the most invaluable tools we all use to solve celestial precomps is the Air Almanac. The amount of data which may be extracted from this publication is voluminous. For the purposes of this article we will only discuss the extraction of GHA and DEC. Normally, the only problem one encounters with the use of this document is the human error of extracting the wrong information. This can be negated by simply being careful. But have you ever encountered that blackest of days when you discover the Air Almanac is missing from the nav kit, or, that you forgot to check its contents and the appropriate page is missing? What can our careless Magellan do to overcome this situation? A professional navigator simply pulls out the HO 249 and starts performing. Every navigator knows how to use the bulk of the star volumes because of much required practice. However, there exists in the back of all three volumes a Table 4 with which the GHA of Aries (Volume 1) or the GHA of the Sun (Volumes 2 and 3) may be readily and easily solved. As a matter of fact, it will be shown how easily this can be accomplished in the next two examples.

The first example involves a computation of the GHA and Declination of the Sun using Volume 3 of the HO 249. The abbreviations and formulae are found on page 337, and both the GHA and DEC will be computed for 17 August 1974 and time of 0723 hours and 30 seconds. The results are:

(table 4a for 1974)

OT (orbit time) = Aug 17^d 07^h - 0.0

(nearest integral hour)

= Aug 17^d 07^h

Table 4	GHA	Dec.
	3^o 57′ (+3)*	N 13^o 37′ 19″ (-19)*
Table 4b	+01′	-06′
	3^o 58′	N 13^o 31′ 19″ (Dec.)

* The entering arguments used in 4b are the nearest hour, and difference between the GHAs and DECs from Table 4. The corresponding sign+/- is also applied.

3^o 58′
285^o 00′ Table 4c for 7^h 20^m
0^o 53′ Table 4d for 3^m 30^s
289^o 51′ (GHA)

	Computer HO 249	Computed Air Almanac
GHA	289^o 51′	289^o 50.4′
DEC.	N 13^o 31′ 19″	N 13^o 31′ 06″

The 249 states that computations using this method are unlikely to exceed an error of two arc minutes, which is within limits in this example. Actually, inflight computations would be made to the nearest ten minutes or hour thus eliminating some of the work involved.

Finally, the GHA of Aries will be determined using Volume 1 (page 320), which is an easier computation than the Sun problem. However, the same basic procedures are used. The date and time are 22 July 1974, and 1947 hours and 45 seconds, respectively. The results are:

Table 4a (First day of month) 1 July 1974	278^o 40′
Table 4b (22 days 19 hours)	306^o 29′
Table 4c (47 minutes 45 seconds)	11^o 58′
	597^o 07′
	-360^o
GHA of Aries: (GHA)	237^o 07′

Computed HO 249	Computed Air Almanac
237^o 07′	237^o 05′ 54″

It should be noted that for Volume 1 (Epoch 1975), the time span is limited to 1972-1980.

The previous examples show that the GHA of both the Sun and Aries can be readily determined by using the HO 249 tables. Examples should be attempted at least once, and the results should be compared between the HO 249 tables and the Air Almanac. The time will be well spent and the benefits include increasing not only navigational ability but also confidence. Furthermore, if a navigator can use all available resources, mission objectives will be definitely enhanced.

After enlistment on 30 September 1963, Captain Hamlin completed electronic/cryptographic training. He was commissioned from OTS in September 1968 and then attended AFIT where he received a master's degree in Electrical Engineering. Captain Hamlin completed both UNT and NBT, followed by SAC assignments at McCoy and Wurtsmith AFBs with TDYs supporting SEA B-52 operations.

Bicentennial Visit To The R.A.F.

Lt Col Don E. KOSOVAC
323 FTW/DOT
Mather AFB CA

When Gator 01 took the active runway at Randolph AFB and began its takeoff roll at exactly 0847L on 19 June 1976, it was the start of a historic flight for Air Training Command and the Air Force. The T-43 made a "first-time-ever" landing outside the United States at Goose Bay, Labrador, Canada enroute to an exchange visit at No. 6 Flying Training School, RAF Finningley UK.

In previous years, the T-43 had made trial fuel runs to Alaska and Hawaii, but the flight to Great Britain in the bicentennial year was special. The mission was part of a reciprocal exchange program begun in 1971 between the navigation training staffs at Mather AFB and RAF Finningley. Brigadier General Melvin G. Bowling, ATC Deputy Chief of Staff for Operations and members of his headquarters staff, including Colonel George W. Engel, Director of Navigator Training, were on board the aircraft. The Mather contingent, headed by Colonel Dennis B. Sullivan, also included Colonel Leo D. O'Halloran, Jr., Deputy Commander for Operations, and training personnel.

Editor's Note: Brigadier General Bolling is now Commander, USAF Recruiting Service, Colonel Sullivan is ATC/DO, and Colonel O'Halloran is 323 FTW Vice Commander.

With the recent ATC acquisition of the T-43 and the significant changes made in RAF ab initio (undergraduate) navigator training, the training staffs had much to talk about. As in the past, the discussions proved highly productive.

Following a course design team effort in which a systems approach to training was applied, the RAF implemented a two stream (track) syllabus for navigation training. Students now enter a 41 week core curriculum where they receive flights in the Bulldog, a low wing version of the T-41, the jet Provost which is similar to the T-37, and the Dominie, the primary navigation aircraft which strongly resembles the T-39. At the end of the core training period, students branch into either a low level, fast mover stream (12 weeks) or a high level airlift stream (10 weeks). Blended into the stream concept is a full survival training package, two weeks leave, and an academic curriculum that stresses in-depth study of navigation theory, computers, and related navigation systems. In this latter respect, the RAF approach to training is balanced by at least equal emphasis on education. This principle is reflected not only in ab initio, but also in the instructor training courses given at Cranwell, the RAF equivalent to the USAF Academy.

Dominie and T-43 at RAF Finningley

The Finningley Hosts

The Mather Contingent

RAF meets ATC

Col Sullivan at T-43 Controls

Perhaps the most striking feature of RAF navigation training is the total involvement of pilots throughout the flight training phase. Since each of the training aircraft is compact, the RAF very nearly approach a 1:1 instructor to student ratio for all missions. This introduces the concept of the operational crew (pilot and navigator) early and places increased responsibility on the student navigator to accurately mission plan and direct the aircraft. With this kind of crew set-up, the pilot has a functional instructor role throughout the entire flight training program. The end result is very intense, realistic training which visiting USAF personnel witnessed and experienced first hand.

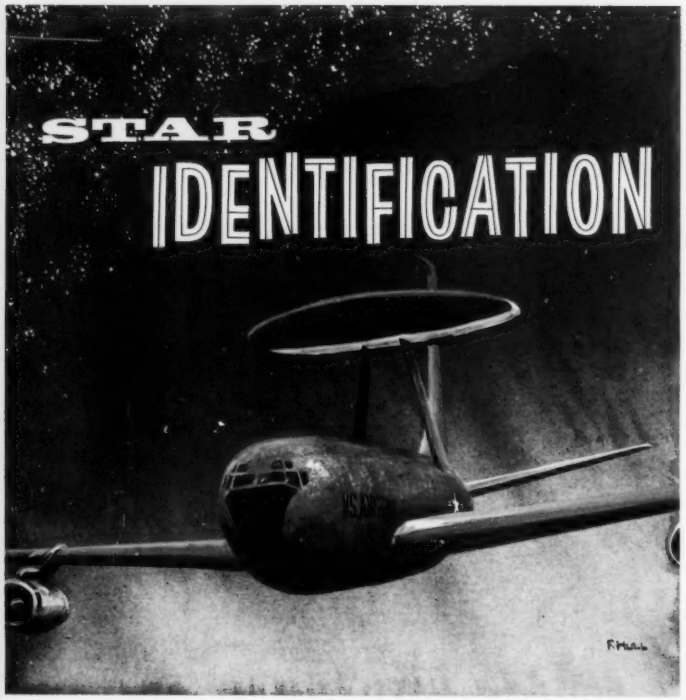
An orientation flight in at least two out of three RAF training aircraft was the highlight of the exchange. For a brief time before and during the flights, USAF personnel experienced something akin to scenes from Dawn Patrol. All became steeped in RAF tradition and routine, beginning with the early crew breakfast in the "flight feeder," the formal mass briefing in mission operations, followed by almost unrestricted flight in the skies over Great Britain.

Wg Cdr Chalmers and Brig Gen Bowling prepare for Bulldog flight

These flights, together with the T-43A sortie received by RAF staff and personnel, illustrated how two contrasting programs are able to arrive at the same objective: training the finest navigators in the world.

The visit stimulated a questioning of training concepts, philosophies, and premises that will help to strengthen our respective programs and relations as professionals doing the same job.

Lt Col Don E. Kosovac graduated from the University of California, Berkeley in 1958. His first assignment was as an administrative officer at Lackland AFB, TX. He graduated from UNT in 1960 and went on to ADC for his first flying assignment in the F-101B. He had follow-on assignments to Air University, PACAF, United States Air Force Academy, Headquarters Command, and Air Training Command. Lt Col Kosovac has an MA in Education from Denver University and is a graduate of Air Command and Staff College. He is presently Chief of Training, Mather AFB.



Editor's Note: Various squadrons have requested reprint rights for the following article which appeared in the Summer/Fall 1969 issues of THE NAVIGATOR. Its author was a Captain Peter A. Cook of Vance AFB, Oklahoma. So that all of you might benefit from these realistic diagrams, we will print this multi-part article in the next two issues.

In order to take an accurate star shot, it is first necessary to shoot the *correct* star. When using a periscopic sextant, the best way to identify the *correct* star is by recognizing the unique "pattern" formed by the stars in the sextant's field of view. In this regard, the star groups that are usually learned, such as the "Navigator's Triangle", the "Arc of Capella", and the "Baseball Diamond", are too large for easy recognition in the narrow field of vision afforded by most sextants.

The charts presented in this article show the field-of-view patterns for Polaris and all the stars listed in HO 249, Volume I. By using these charts and their accompanying tables, the observer can predict exactly what he will see when looking for a particular star.

Each chart shows the 1st, 2nd, 3rd, and 4th magnitude stars that are visible with a sextant with a 15^0 field of view when the desired star is in the center. On a clear night many more will be visible; on a hazy or moonlit night only the brightest will show. Lines were included to make the patterns more meaningful. Most of these follow the lines of the better known constellations.

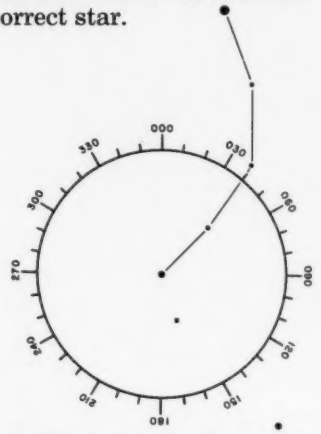
The stars are shown as they would appear from the North Pole. For other latitudes, the accompanying tables of position angles tell how much the charts should be rotated to give the correct presentation for the time of the observation. Dashes indicate that the star is below the horizon at those points.

To use the charts, enter the table with the closest values of latitude and LHA of Aries to find the position angle. Then rotate the chart until this position angle is at the top. The star pattern which results is the one which will appear in the sextant.

As an example, say you want to shoot Polaris. Your latitude is 42^0 N and your precomp sheet shows the LHA of Aries to be 159. Entering the Polaris table with the nearest values of latitude and LHA (40^0 N and 150) you find the position angle to be 302. Though interpolation can be used for greater accuracy, it is not usually necessary.

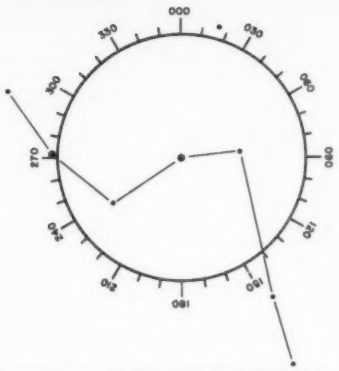
Then take the Polaris chart and turn it until 302 is at the top. In this position, the handle of the "Little Dipper" will stretch out to the right. Now turn the sextant to the precomputed bearing and altitude and look for this pattern. When you see the handle of the dipper leading off to the right, you can easily locate Polaris and will be certain that you are shooting the correct star.

POLARIS



LHA / LAT	0	30	60	90	120	150	180	210	240	270	300	330
80N	143	180	217	251	281	309	335	000	025	051	079	109
70N	147	180	213	245	276	305	333	000	027	055	084	115
60N	148	180	212	243	274	303	332	000	028	057	086	117
50N	149	180	211	242	273	302	331	000	029	058	087	118
40N	149	180	211	242	272	302	331	000	029	058	088	118
30N	149	180	211	242	271	300	331	000	029	060	089	118
20N	149	180	211	240	270	300	331	000	029	060	090	120
10N	149	180	211	240	270	300	331	000	029	060	090	120
0	149	180	211	240	270	300	329	000	031	060	090	120
10S	-	-	-	-	-	-	-	-	-	-	-	-
20S	-	-	-	-	-	-	-	-	-	-	-	-
30S	-	-	-	-	-	-	-	-	-	-	-	-
40S	-	-	-	-	-	-	-	-	-	-	-	-
50S	-	-	-	-	-	-	-	-	-	-	-	-
60S	-	-	-	-	-	-	-	-	-	-	-	-
70S	-	-	-	-	-	-	-	-	-	-	-	-
80S	-	-	-	-	-	-	-	-	-	-	-	-

ACAMAR

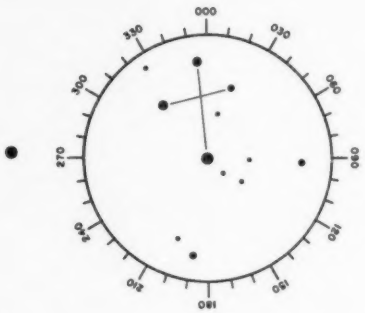


LHAT / LAT	0	30	60	90	120	150	180	210	240	270	300	330
80N	-	-	-	-	-	-	-	-	-	-	-	-
70N	-	-	-	-	-	-	-	-	-	-	-	-
60N	-	-	-	-	-	-	-	-	-	-	-	-
50N	-	-	-	-	-	-	-	-	-	-	-	-
40N	032	011	348	327	-	-	-	-	-	-	-	-
30N	037	013	345	321	-	-	-	-	-	-	-	-
20N	044	015	343	320	-	-	-	-	-	-	-	-
10N	050	018	340	309	286	-	-	-	-	-	-	072
0	056	022	336	302	279	-	-	-	-	-	-	079
10S	065	026	330	293	271	-	-	-	-	-	-	087
20S	076	035	321	283	262	245	-	-	-	-	114	096
30S	088	053	302	270	254	238	-	-	-	-	121	105
40S	105	095	265	255	243	230	-	-	-	147	129	114
50S	123	140	223	237	232	222	207	189	170	152	138	127
60S	141	161	201	220	220	212	201	187	172	158	147	140
70S	157	171	190	203	206	203	195	185	175	164	156	154
80S	169	176	185	191	193	192	189	183	176	171	168	167

ACHERNAR

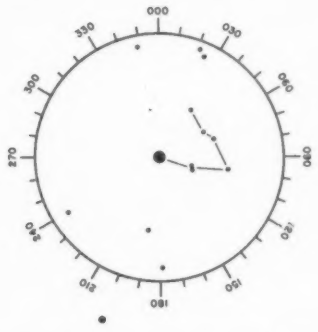
LHAT / LAT	0	30	60	90	120	150	180	210	240	270	300	330
80N	-	-	-	-	-	-	-	-	-	-	-	-
70N	-	-	-	-	-	-	-	-	-	-	-	-
60N	-	-	-	-	-	-	-	-	-	-	-	-
50N	-	-	-	-	-	-	-	-	-	-	-	-
40N	-	-	-	-	-	-	-	-	-	-	-	-
30N	-	355	-	-	-	-	-	-	-	-	-	-
20N	023	354	326	301	-	-	-	-	-	-	-	-
10N	025	354	323	295	-	-	-	-	-	-	-	054
0	028	353	320	290	-	-	-	-	-	-	085	059
10S	030	352	315	285	260	-	-	-	-	-	090	063
20S	035	351	310	280	255	229	-	-	-	121	096	070
30S	041	349	303	272	249	225	201	-	150	126	103	077
40S	051	346	292	264	242	221	199	175	153	131	110	086
50S	071	334	275	252	234	215	196	176	157	137	118	099
60S	109	234	248	238	224	210	194	177	160	144	130	118
70S	149	189	218	220	213	202	190	178	164	153	144	140
80S	169	183	194	199	197	193	187	179	171	165	162	162

ACRUX



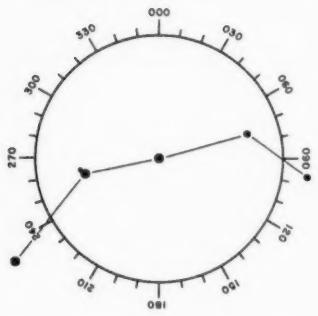
LHAT / LAT	0	30	60	90	120	150	180	210	240	270	300	330
80N	-	-	-	-	-	-	-	-	-	-	-	-
70N	-	-	-	-	-	-	-	-	-	-	-	-
60N	-	-	-	-	-	-	-	-	-	-	-	-
50N	-	-	-	-	-	-	-	-	-	-	-	-
40N	-	-	-	-	-	-	-	-	-	-	-	-
30N	-	-	-	-	-	-	-	-	-	-	-	-
20N	-	-	-	-	-	034	005	337	-	-	-	-
10N	-	-	-	-	064	036	007	335	307	-	-	-
0	-	-	-	-	068	039	007	334	303	276	-	-
10S	-	-	-	100	073	043	008	331	299	271	-	-
20S	-	-	130	105	079	047	008	328	293	266	240	-
30S	185	159	135	110	085	053	010	323	287	260	235	210
40S	185	161	138	116	092	061	012	315	279	254	230	208
50S	184	164	143	123	102	075	019	301	267	245	225	204
60S	183	166	149	132	120	100	059	269	250	234	218	201
70S	182	169	156	144	136	135	166	220	226	219	209	197
80S	182	173	166	160	158	163	177	192	201	201	197	190

ALDEBARAN



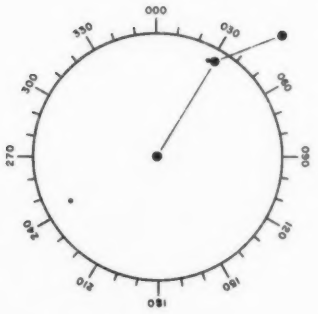
LHAT / LAT	0	30	60	90	120	150	180	210	240	270	300	330
80N	009	006	001	356	351	349	350	354	358	004	008	010
70N	020	014	003	351	342	340	342	348	-	-	016	021
60N	031	023	005	345	332	329	333	-	-	-	-	031
50N	042	033	009	337	322	318	-	-	-	-	-	040
40N	053	047	015	325	309	308	-	-	-	-	-	049
30N	064	061	026	308	296	298	-	-	-	-	-	059
20N	075	078	061	284	283	287	-	-	-	-	-	-
10N	086	095	127	258	270	277	-	-	-	-	-	-
0	097	109	153	236	258	268	-	-	-	-	-	-
10S	106	122	163	222	247	258	-	-	-	-	-	-
20S	116	133	167	212	237	248	-	-	-	-	-	-
30S	125	142	171	205	227	-	-	-	-	-	-	-
40S	134	149	173	199	218	-	-	-	-	-	-	-
50S	144	156	174	195	211	-	-	-	-	-	-	-
60S	-	162	176	191	203	-	-	-	-	-	-	-
70S	-	168	177	187	-	-	-	-	-	-	-	-
80S	-	-	-	-	-	-	-	-	-	-	-	-

ALIOTH



LHA↑ LAT→	0	30	60	90	120	150	180	210	240	270	300	330
80N	357	004	011	016	018	015	005	354	345	342	345	350
70N	354	007	018	029	036	036	019	339	323	324	331	342
60N	352	008	025	040	052	062	056	302	299	309	321	337
50N	350	011	030	048	066	084	119	244	277	296	313	331
40N	350	013	034	055	076	100	132	220	262	285	306	327
30N	-	-	038	062	084	111	153	211	251	278	300	323
20N	-	-	-	067	091	119	158	205	242	270	295	-
10N	-	-	-	073	098	126	161	202	236	264	289	-
0	-	-	-	-	103	131	163	199	232	259	-	-
10S	-	-	-	-	109	135	165	197	227	-	-	-
20S	-	-	-	-	-	139	166	195	222	-	-	-
30S	-	-	-	-	-	-	168	193	-	-	-	-
40S	-	-	-	-	-	-	-	-	-	-	-	-
50S	-	-	-	-	-	-	-	-	-	-	-	-
60S	-	-	-	-	-	-	-	-	-	-	-	-
70S	-	-	-	-	-	-	-	-	-	-	-	-
80S	-	-	-	-	-	-	-	-	-	-	-	-

ALKAID



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60N	346	002	017	032	044	050	046	348	310	311	319	332
50N	343	003	022	039	054	068	080	271	283	296	309	325
40N	340	003	025	045	064	082	109	197	260	283	300	319
30N	-	-	-	052	073	094	125	190	244	272	293	314
20N	-	-	-	057	080	103	136	187	234	263	286	-
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20S	-	-	-	-	-	128	155	184	213	237	-	-
30S	-	-	-	-	-	-	158	183	209	-	-	-
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50S	-	-	-	-	-	-	-	-	-	-	-	-
60S	-	-	-	-	-	-	-	-	-	-	-	-
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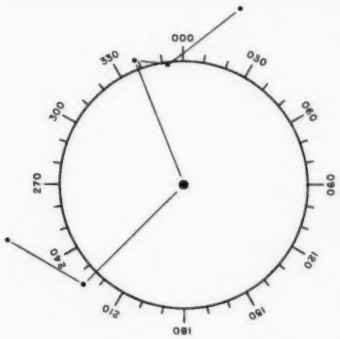
ALPHARD



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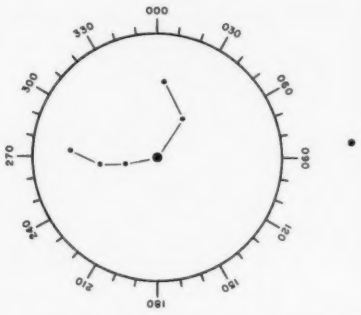

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50N	329	-	-	-	036	044	045	031	351	321	314	318
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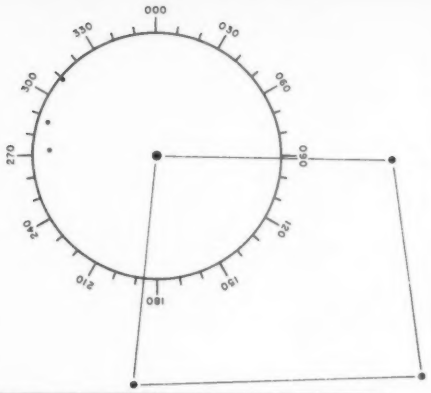

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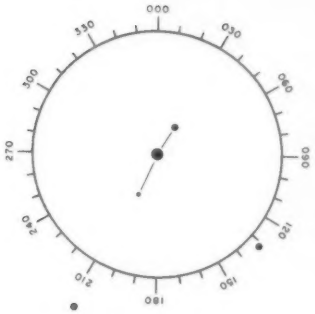
ALTAIR



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40N	311	310	-	-	-	-	-	051	048	034	357	323
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60S	206	-	-	-	-	-	-	-	154	166	181	196
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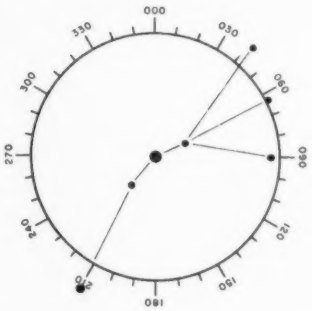
ANTARES



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60S	207	197	-	-	156	148	147	154	175	199	212	213
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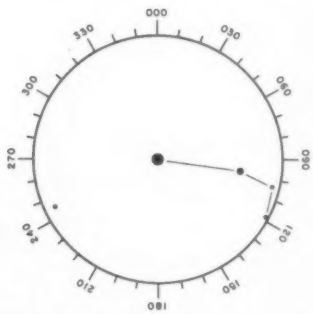
ARCTURUS



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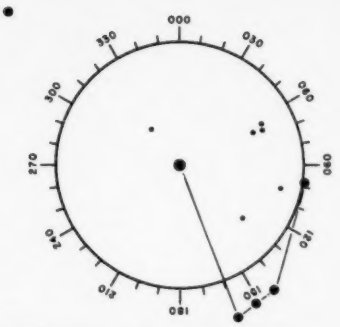
BETELGEUSE



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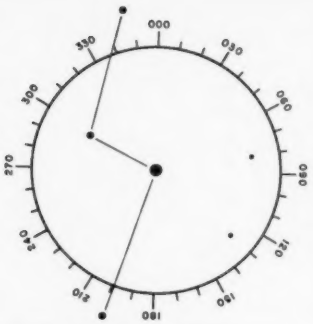

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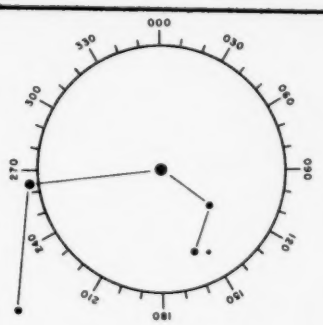
CAPELLA



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60S	-	-	-	-	-	-	-	-	-	-	-	-
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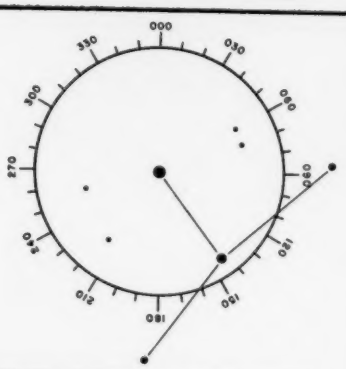
DENEB



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70N	332	331	336	345	356	007	018	026	030	025	009	345
60N	314	318	327	340	355	010	025	036	045	045	019	327
50N	295	306	319	335	353	012	031	045	058	067	055	293
40N	279	295	311	331	-	-	036	054	070	087	126	255
30N	265	286	305	-	-	-	042	061	080	103	151	231
20N	255	277	298	-	-	-	-	069	090	114	159	219
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0	239	263	-	-	-	-	-	-	104	130	166	207
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60S	-	-	-	-	-	-	-	-	-	-	-	-
70S	-	-	-	-	-	-	-	-	-	-	-	-
80S	-	-	-	-	-	-	-	-	-	-	-	-

THE TEAM:

operations and maintenance

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93 AREFS
Castle AFB CA

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Castle AFB CA

At times we flying types get so involved in our daily problems, we lose sight of our goal...to fly and train for the EWO mission. Under the wing organization structure, many agencies support this goal. No two agencies are as dependent on each other as are maintenance and operations. Without the machine or without the crew, we cannot accomplish our goal.

As the aircraft get older, the need for a good working relationship between operations and maintenance increases. How can we work together to accomplish our common goal? This article (based on KC-135 Navigator Systems) may help us all in our daily efforts to improve our own capability.

The key to an effective maintenance-operations relationship is the currency and accuracy of the information flow. Though the following results are oriented toward navigation equipment and avionics maintenance, the concepts are universal and apply to all systems and subsystems.

How do we achieve current and accurate information flow? The following are some brief examples of what maintenance and operations need.

OPS Needs From Maintenance

1. A total history of every aircraft system for each aircraft would be helpful to a crew in planning the specific accomplishments of a particular mission. Backup plans can be made for a known system that has a high failure rate.
2. Availability of specialists or supervisors who can explain maintenance in terms of operator terminology.
3. Meaningful briefings from a qualified maintenance technician in conjunction with the Form 781 review. This should be accomplished during the early stages of preflight so that complete evaluation of open malfunctions can be accomplished.
4. Maintenance personnel should have an understanding of how the operators use the equipment. For example, recently a nav radar repeatedly blew fuses inflight, but maintenance personnel (using explicit tech order procedures) were unable to duplicate the malfunction. It was accidentally discovered that the navigator always ran the set in PPI (fast scan) while maintenance used RIGHT (slow scan) when testing. When maintenance used PPI the fuse blew and the malfunctioning subassembly was quickly identified.
5. Specialized ops orientation briefings on equipment modifications and special equipment test programs. Maintenance should coordinate with operations while planning these briefings to insure that anticipated ops questions can be answered adequately.

Maintenance Needs From OPS

1. Clear, precise, complete written descriptions of aircraft malfunctions. Such information as altitude, heading, and aircraft configuration greatly aid the speed and accuracy of the repair action. Avoid words like "shaky," "inop," "malfunctions," and "doesn't work." Be specific. Include any special information which only you, as a crewmember, would know—such as a power surge just prior to the malfunction.
2. Be sure the oral descriptions given the debriefer are clear and that the debriefer understands all your write-ups before you leave.
3. Detailed descriptions of discrepancies that occur during preflight or that are unable to be cleared by flight time. Call in these discrepancies as soon as discovered. The operator can often identify a specialized need for a particular unit that maintenance would be unable to anticipate, and this unit should be identified during the call-in.
4. Aircrew members should have complete understanding of the malfunction and inflight maintenance checklists available to them. This not only assists the operator, but also helps provide necessary background information for maintenance when requesting air to ground assistance.
5. Complete and accurate attention to all forms and records required in conjunction with new equipment modifications and test programs. These forms are often the basis for final modifications prior to fleet-wide installation.

There are some other things that your unit can do to improve togetherness. Specialists from one field can present briefings on current topics and problem areas to the other side. For example, a specialist from avionics and his supervisor could have a presentation at your instructor meetings. Your squadron navigation staff could present current unusual mission requirements to the shop supervisor at informal sessions in the maintenance squadrons. This small investment reaps many dividends in mission orientation and could make the critical difference in mission success.

Another idea we use at Castle is a newsletter. It is called the AVIONICS NEWS and was developed by the Avionics Squadron as an informal vehicle for cross-feed of avionics related information between crewmembers and technicians. Both ops and maintenance contribute material for publication and distribution to both agencies. Having a point of contact on both the crewmember side of of the house and on the maintenance side is extremely effective as long as the cross-feed is kept at the working level.

Hopefully, you can see that the key to a good ops-maintenance relationship is communication. Problems will arise. Man-made products will eventually malfunction. Do you maintenance people believe the operators cause these malfunctions? Have you operators ever suspected that maintenance people couldn't fix it? At times you both may have been right. By effective communications we can educate each other with the net benefit being a safe, reliable airframe that can provide the best training.

We have presented some ideas that we are using at Castle. Hopefully, we have suggested some programs that may work in your unit. Better yet, you may have some better ideas. Let us know...we'll respond to all inquiries and will send copies of our Avionics News, if desired.

Whatever your method, the only solution to our complex systems and mission requirements is **THE TEAM: OPERATIONS AND MAINTENANCE.**

Major Stetson is a native of Great Neck, Long Island, NY. He entered the Air Force in 1958 through the Aviation Cadet Program. His first operational assignment was at Forbes AFB, where he flew the KC-97. In 1965, he retrained into the KC-135, and upgraded to instructor navigator the following year. Major Stetson presently is an instructor navigator at the SAC KC-135 Combat Crew Training School.

A native of San Diego, Major Johnson entered the Air Force in 1962 and was commissioned through OTS. He then served in maintenance at Homestead AFB, Kadena AB, and as a Task Force Commander at Utapao, TH. In 1968, he graduated from UNT, followed by assignments to Grand Forks and Castle AFBs as a CCTS Instructor Navigator. Major Johnson was again assigned to maintenance in May 1975, and now serves as a Maintenance Supervisor.

Mather gets a NAVIGATOR COMMANDER

Colonel Attilio Pedroli became the 323d Flying Training Wing Commander in a noteworthy change of command ceremony on 13 September 1976, at Mather Air Force Base, California. Why noteworthy? He is the first navigator to command a flying wing.

Colonel Pedroli's Air Force career began when he enlisted in March 1951. After completing basic training, basic electronics school, and radar maintenance school, he entered basic observer training at Harlingen, Texas, as an aviation cadet in June 1952. He then attended advanced radar navigator training at Sheppard AFB, Texas, and received his navigator wings and Air Force commission as a second lieutenant in May 1953.

Until 1964, Colonel Pedroli performed various air crew duties flying B-29, B-36, and B-52 aircraft with the Strategic Air Command. Two career broadening staff assignments at Wright-Patterson AFB, Ohio followed – Chief, Target Intelligence Branch and Maintenance Supervisor, 17th Armament and Electronic Squadron.

Next he entered the Air Command and Staff College in August 1966. Upon graduation in June 1967, he was assigned to EB-66 crew duty with the 355th Tactical Fighter Wing, Takhli AB, Thailand, with a short stop at Shaw AFB on the way to check out in the EB-66. While at Takhli, he flew 119 combat missions and served as the squadron staff navigator.

Colonel Pedroli was assigned to Mather Air Force Base, California, in late 1968 and attended navigator instructor training. He then served as a Squadron Flight Commander, Base Executive Officer, and Commander, 3538th Navigator Training Squadron (now the 450th Flying Training Squadron).

He left Mather in 1971 to become Commander, 7005th Air Base Squadron, Stuttgart, Germany, where he provided airlift support for Headquarters, US European Command. In January 1973, he joined HQ USAFE, Ramstein Air Base, Germany, as a radar systems staff officer. He also served as Deputy Base Commander and then Base Commander at Ramstein.

Assigned back to Mather as the Deputy Commander for Operations, he soon found himself moving into the Vice Wing Commander's Office in October 1975. He served in this position until his selection as the 323d Flying Training Wing Commander.

Colonel Pedroli is a master navigator with over 6,000 flying hours. Among his decorations are the Silver Star, Distinguished Flying Cross, Bronze Star, Meritorious Service Medal with one oak leaf cluster, Air Medal with seven oak leaf clusters, Purple Heart, and the Combat Readiness Medal.

He is married to the former Georga Crystal of Vacaville, California. They have six children – four boys and two girls.

THE NAVIGATOR joins everyone in congratulating Colonel Pedroli on his new assignment. This personal accomplishment shows again that navigators with proven abilities now have equal opportunities for command positions.

The Editor

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